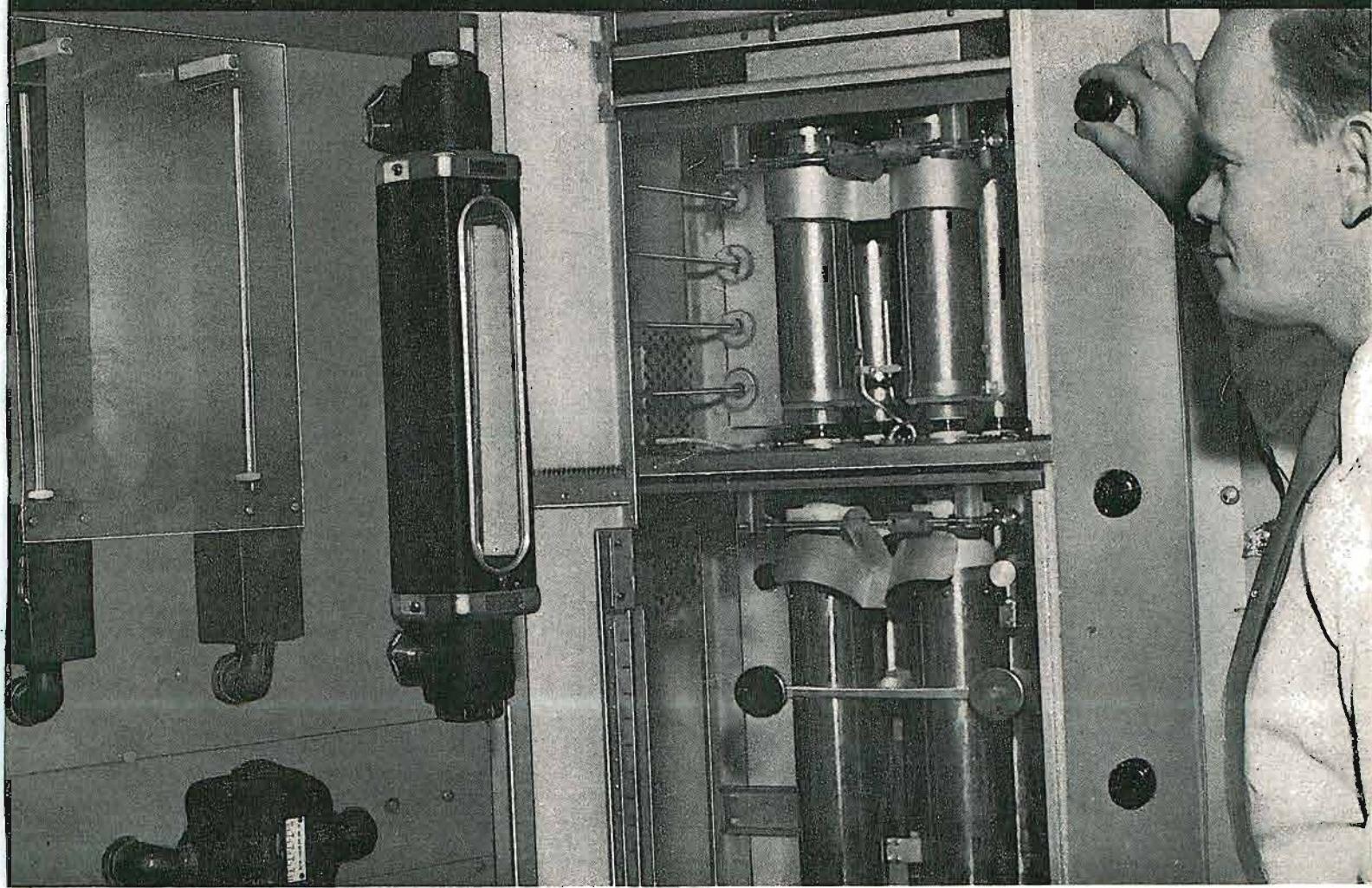


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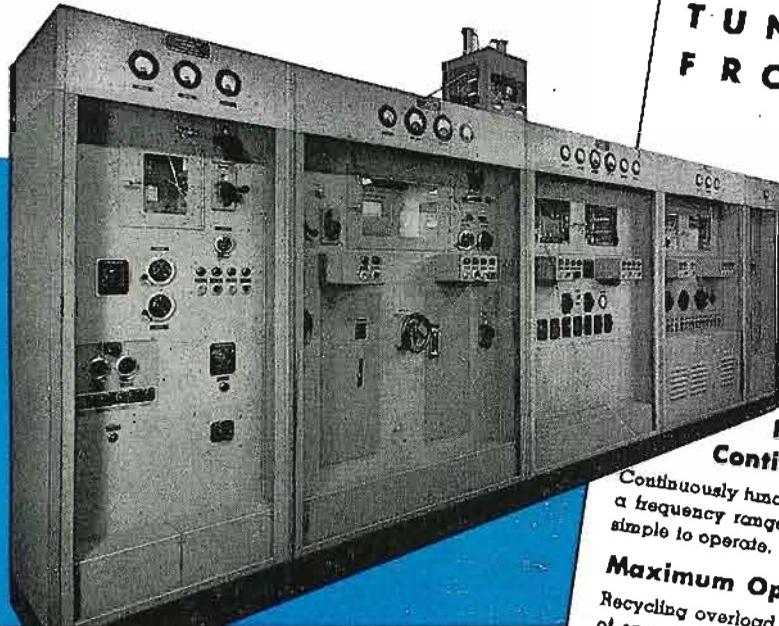
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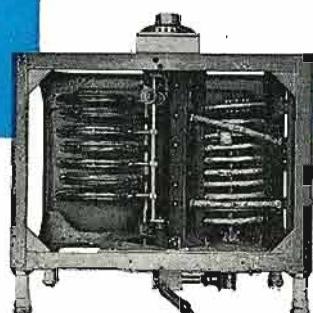
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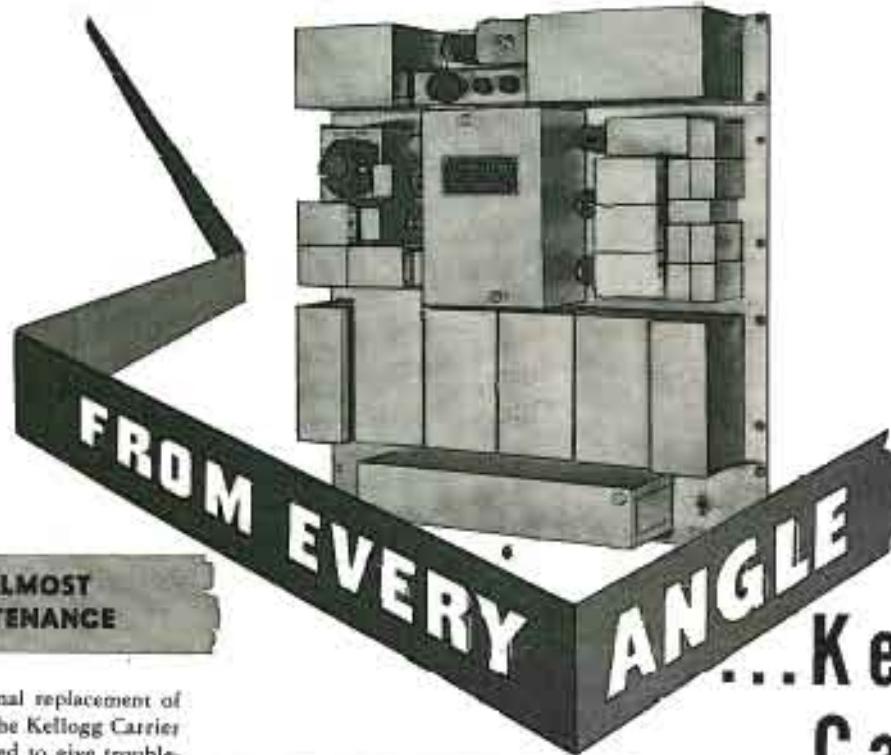
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Tuning final power-amplifier stage of mid-level modulation type TV transmitter.

(Courtesy Federal Telecommunications Laboratories;
Photo by Bill Bartow.)

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TIME RECEIVED	A P	BY	TRouble FOUND	DATE OK	TIME	A P	BY				
<i>He can see a thousand miles</i>											
SYNCHRONIZATION - START					CA FAIL SEND CKT.		STATION IDENTIFICATION				
ON	ON	OFF	ON	ON	CHAN. 1 SECT						
SYNCHRONIZATION - STOP					FUEL GAS LOW						
ON	ON	OFF	ON	ON							
FUSES		24-VOLTS			ABS						
DISCH.	DIST.	H-L VOLT	REG. FAIL	24V 130V	48V						
POWER CONTROL PANEL FAILURE											
201- 202W	203- 204W	205- 206W	207- 208W	201- 202E	203- 204E						
ALT. CONT. BAY - NO VOLT. OUT.				NO VOLT. - TRAN							
201 202	203 204	205 206	207 208	201 202	203 204						
RECT. FAIL 24/130V	48 V H-L VOLT			RECTIFIER-INVERTER FAIL							
				NO. 1	NO. 2	NO. 3					
64 KC PILOT ALARM AT NON-SW. MAIN								3096 (WKG. LINE) PILOT AT SW. MAIN			
201	202	203	204	205	206	207	208	201	205	202	206
2064 KC PILOT ALARM AT NON-SW. MAIN								3096 (SP. LINE) PILOT AT SW. MAIN			
201	202	203	204	205	206	207	208	201	205	202	206
3096 KC PILOT ALARM AT NON-SW. MAIN								SP. LINE FAIL AT SW. MAIN			
201	202	203	204	205	206	207	208	201	205	202	206
TOT. LINE FAIL AT SW. MAIN				AUTO. SWITCH AT SW. MAIN				AUTO. SW. LOCKED AT SW. MAIN			
201 203	205 207	202 204	206 208	201 203	205 207	202 204	206 208	201 203	205 207	202 204	206 208



CARRYING hundreds of telephone calls, coaxial cable runs through many lonely miles. Far from towns and people, master amplifying stations stand guard with a new automatic alarm system developed by Bell Telephone Laboratories.

At a city terminal, the man on duty makes a check by laying a transparent log sheet over a glass window, and dialing a master station hundreds of miles away. At once the station begins to give an account of itself, lighting lamps under the log sheet to report any abnormal operating condition before it becomes an emergency.

But when something happens that threatens serious trouble, the apparatus acts at once—maybe by switching in a spare coaxial—and calls a distant test board by ringing a bell. Sometimes he can take further steps by remote control; if not, he knows exactly how to brief the nearest repair crew.

With this new alarm system, maintenance men need not be stationed at isolated points, just waiting for something to happen. Instead, they live in their home communities. This makes for better work...and better telephone service.



COMMUNICATIONS

LEWIS WINNER, Editor

SEPTEMBER, 1949

FM Video

TV ENGINEERING progress, which will be examined with microscopic detail by the largest group of authorities ever assembled, at the forthcoming revised veryhigh and ultrahigh allocation conference in Washington, will have a vibrant record to offer with many striking trends illustrated.

For instance, there'll be testimony from such experts as Washington consultant Raymond Willmotte, who believes that the relative merits of frequency versus amplitude modulation in TV have until recently been very much neglected, and that FM provides a definite solution to the many problems that now exist. Recalling the tests of Chapin of the FCC, we are told that in co-channel interference ratio, adjacent-channel interference ratio, and in short-time ghosts, FM was found superior to AM. Only in long-time ghosts did AM appear to offer better results. However, comments Willmotte, in co-channel operation FM appeared superior even to offset frequency AM in the Chapin study.

Probing the FCC trials further, Willmotte declares that it was found that in AM there is a very sharp peak of energy in the band. The wide bandwidth is nevertheless required, so that the low energy levels at the extreme edges of the band which are important for the picture, may be received. With FM, the energy is much more uniformly distributed, and accordingly FM is inherently capable of using the band allocated to it, more usefully than AM, states Willmotte. In practice this factor should be reflected in the form of improved desired-to-undesired signal ratio, reduced power to overcome noise, etc. Commenting on sync pulse power, Willmotte states that AM requires a peak power of about 1.8 times the maximum power needed in the picture, a high-power condition that does not prevail in FM.

According to Willmotte, FM would also afford better results if new circuits were developed to provide the use of preemphasis, which has been found to be of considerable importance in FM performance, and the application of

better limiters and improved discriminators to reduce adjacent channel interference. There is also the suggestion that designers consider other means of transmitting the sync pulse, and yet retain its character after the limiter and discriminator.

Investigations conducted by this Washington consultant also reveal that new basic concepts have been discovered which reaffirm the belief that FM is better for TV. These concepts are based on the fact that there are two parameters which define a signal, amplitude and frequency. In FM only one parameter is used to transmit the intelligence. Therefore, notes Willmotte, the engineer is free to operate on this unused parameter to obtain some specially desired results. Thus, separation of desired-to-undesired signal might be improved considerably, a vital point which could reduce the beat type of interference experienced when FM is operated on a narrow band, and also permit closer separation of co-channel stations.

In view of these findings, Willmotte has petitioned the FCC to indicate the interest it has in FM and postpone the establishment of ultrahigh standards until there has been an opportunity to compare properly the relative merits of AM and FM.

The possibilities of FM video have been commented on favorably by others who are expected to pilot the subject to a key debate at the hearings.

Public Safety Communications

IN A SIGNIFICANT report, at the recent APCO conference in New York City, on the status of police radio, Daniel Noble of Motorola, offered some illuminating predictions on tomorrow's designs.

According to Noble, the advancement of the art will make it entirely practicable to split the 152-162 mc. 60-kc channels into three 20-kc channels.

"The problem is not one of intermodulation and selectivity . . . but simply a problem of circuit and crystal oscillator stability," said Noble.

"I have already operated three sta-

tions, separated by only 20 kc successfully, with performance comparable to that achieved with three stations operating on adjacent 60-kc channels. . . . It is not inconceivable that, in the future, the 30 to 50-mc band will utilize 10-kc channels successfully, and that in the 152 to 162-mc band, 20-kc channel separation will be the rule."

Discussing the future of higher power for state police, Noble said that if he were setting up the systems, he would designate 20-kc semi-cleared channels and establish the primary power on the main stations at a maximum of 5 kw to provide a suitable db improvement over the usual quarter kilowatt. Intelligent use of the 20-kc channels in this type of application can result in a reduction in the possible skywave, by the proper geographical separation of channel assignments, Noble reported.

Covering the possibilities of microwaves for police setups, Noble stated that while the cost of such equipment at present is a forbidding factor, over the years it should be possible to install an ever-expanding network of multiplex microwave systems, connecting state, city, county, police and interconnecting among states. Such a tieup, he said, would provide an independently controlled national network of microwave and mobile communications to coordinate the safety services of the country. The building of such a system would be the final step in the design of the ultimate in mobile communications for national security, declared Noble.

Above 50 Mc

A BUREAU OF STANDARDS text, which will undoubtedly become a standard of reference at the TV allocation sessions, is now on file at the FCC. Prepared by Kenneth A. Norton of the Bureau and Harry Fine of the FCC and covering a study of methods for the efficient allocation of radio frequencies above 50 mc, the report reveals that a maximum total coverage of area can be obtained with a limited number of channels by locating them geographically in a triangular lattice with a co-channel separation of the order of 100 to 300 miles.

A complete review of this important analysis will appear in the October issue of *Communications*. Watch for it.—L. W.

HELICAL BEAM ANTENNA

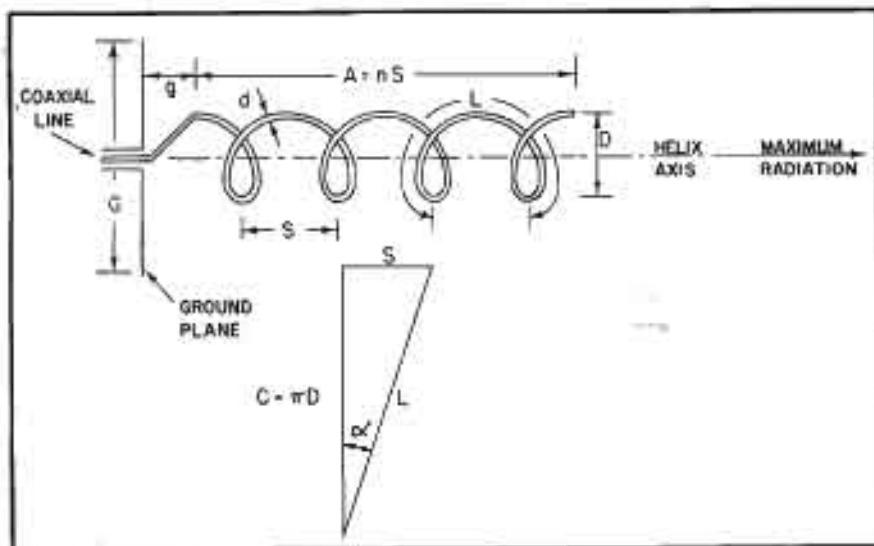


Figure 1
Helical beam antenna with dimensional symbols.

THE HELICAL BEAM ANTENNA (a helix radiating in the axial mode) provides a well-defined end-fire beam which is almost circularly polarized. Minor lobes are relatively small. Its mode of radiation is readily produced by a conductor formed as a helix of 5° to 20° pitch angle on a cylinder about one wavelength in circumference. The axial mode has the unique property that it may persist over a considerable frequency range with desirable pattern and impedance characteristics.

The axial or end-fire mode of radiation of the helix is most simply generated by the coaxial line and ground plane arrangement shown in Figure 1, with the inner conductor connected to one end of the helix and the outer conductor terminated in a ground plane. The ground plane may be made of solid sheet, of screen, or of a number of radial and concentric conductors.

Preliminary Design Considerations

It will be assumed that for a certain application either a definite beamwidth or a particular value of power gain is desired. Actually the beamwidth and gain are interdependent so that if a

Simplified Procedures Developed With the Aid of Easily Applied Formulas Which Provide Beamwidth, Gain, Axial Ratio and Terminal Resistance. Methods of Calculating Patterns Included in Novel Approach to Design Problems.

by JOHN D. KRAUS

Associate Professor of Electrical Engineering
Ohio State University

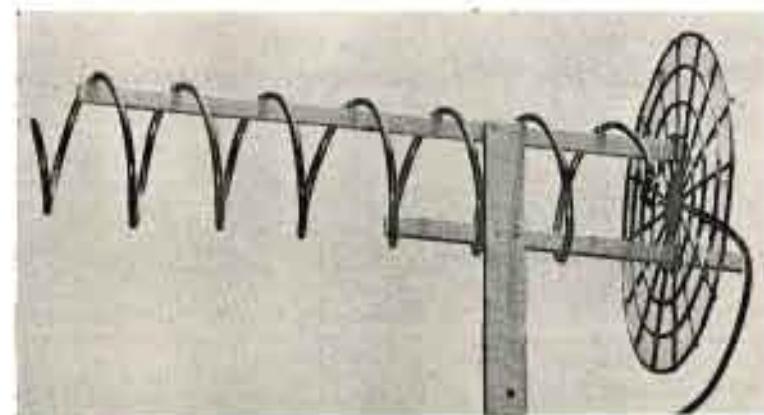
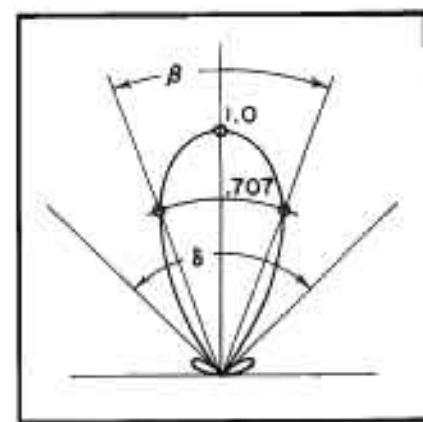


Figure 2 (Below, left)
Pole-mounted helical beam antenna, showing construction.

Figure 3
Relative field pattern with beamwidth between half-power points (β) and beamwidth between first nulls (δ).



Design Techniques

certain power gain is chosen, the beamwidth is, for practical purposes, determined and vice versa. An optimum design for a medium-gain helical beam antenna, previously described,¹ provides a pitch angle (α) of 14° and 6 turns. Although the difference in characteristics between antennas of 12° to 15° pitch angle is not large, the smaller angle (12°) gives slightly better patterns (sharper main lobe and smaller minor lobes for a given axial length, nS) while the larger angle (15°) gives a slightly smaller resistance variation over the bandwidth. The choice of a particular pitch angle involves a compromise and any value selected is entirely arbitrary. In this paper, 12.5° has been taken as the preferred value of the pitch angle (α).

At the center frequency of operation it is convenient to make the circumference (C) of the helix about 1 wavelength. Since the circumference, C , is equal to π times the diameter, D , of the helix, $C = \pi D$. And since the circumference is 1 wavelength at the center frequency, the diameter D at the center frequency should be

$$D = \frac{\lambda}{\pi} = 0.32 \lambda$$

where λ is the free-space wavelength. Referring to Figure 1, we find that the expression for the spacing, S , is $S = C \tan \alpha$. For $\alpha = 12.5^\circ$ the value of the spacing at the center frequency should then be

$$S = 0.22 \lambda$$

The ground plane diameter, G , should be about 0.8 wavelength or more. Assuming that the feed arrangement is as shown in Figure 1, the spacing, g , between the ground plane and the helix proper (of length nS) should be about one-half the turn spacing ($g = S/2$). In Figure 1, the coaxial line is coincident with the helix axis and the connection between the coaxial line and the helix proper consists of a straight section of conductor of the same kind as used for the helix. Construction is simplified by making it simply a continuation of the helix conductor. The diameter, d , of this conductor is not critical, but can be taken to be of the order of 0.02 wavelength at the center frequency. Thus, for example, the conductor diameter of a helix designed for a center frequency of 400 mc would be about $1/16$.

To summarize, the helical beam antenna may be designed with the follow-

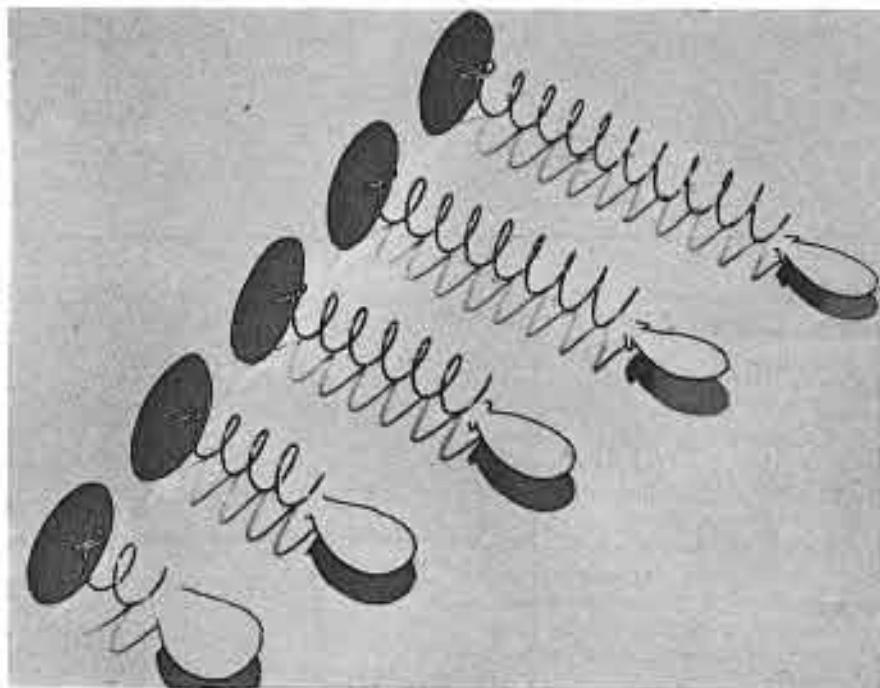


Figure 4
Models showing effect of number of turns of helix on measured field patterns. Helices have 12.5° pitch angle and 2, 4, 6, 8, and 10 turns.

ing dimensions regardless of the gain or beamwidth desired;² all dimensions are expressed in terms of the free-space wavelength at the center frequency of operation:

Diameter . . . $D = 0.32 \lambda$
Spacing . . . $S = 0.22 \lambda$
Ground plane diameter . . . $G \geq 0.8 \lambda$
Conductor diameter . . . $d = 0.02 \lambda$
Spacing from ground plane to first turn . . . $g = S/2 = 0.12 \lambda$

The only remaining quantity which must be specified is the number of turns, n , and this is determined by the desired beamwidth or gain.

The bandwidth over which the antenna will radiate in the axial mode is from about 0.75 to 1.3 of the center frequency, giving a total bandwidth of about 1.75 to 1.

Beamwidth and Gain Expressions³

Based on the measured patterns of a large number of helical beam antennas

²The only exception might be for low-gain helices, of 1 turn or less, for which the expressions presented in the following text do not specifically apply.

³Beamwidth and gain formulas are first offered for the more general case of any wavelength within the bandwidth of operation and also for any pitch angle (α) between 12° and 15° . The formulas are then specialized to give the values at the center frequency ($C = 1.0 \lambda$) and for a pitch angle of 12.5° . Finally, these equations are restated so that the number of turns required is expressed in terms of the beamwidth or gain desired. This number of turns, n , with the other dimensions listed in the preceding section completely specifies the 12.5° helix.

it is found that the beamwidth (β) between half-power points (Figure 3) is given quite closely by the very simple relation

$$\beta = \frac{52}{C \sqrt{\frac{nS}{\lambda}}} \text{ degrees} \quad (1)$$

Where:

λ = free-space wavelength

S = spacing = $C \tan \alpha$

C = circumference, and

n = number of turns

The wavelength, spacing, and diameter are, of course, all measured in the same units. It is assumed that the pitch angle is between 12° and 15° , that n is at least 3, and that the circumference is between $3/4$ and $4/3$ wavelengths. It may be shown analytically that the beamwidth of long end-fire arrays is

proportional to $1/\sqrt{\frac{nS}{\lambda}}$. The factor

$52/C$ in (1) has been determined empirically. The beamwidth given by (1) applies to the radiation pattern for either the vertically or the horizontally-polarized component of the electric field intensity, but most closely with the average of the two.

As examples of the application of formula (1), half-power beamwidths

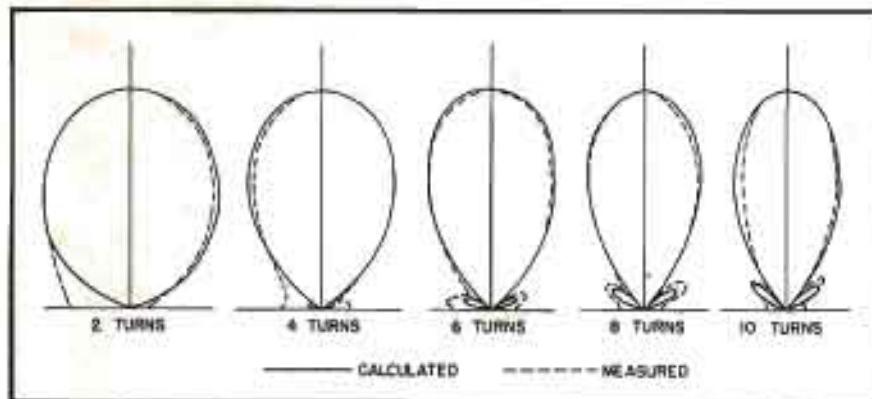


Figure 5

Calculated field patterns of 12.2° helical beam antennas (solid lines) of 2, 4, 6, 8, and 10 turns with measured patterns (dashed lines) for comparison.

(β) calculated by this relation are listed in table I for 12.2° helices of 2, 4, 6, 8, and 10 turns with $C = 0.98 \lambda$ and $S = 0.21 \lambda$. Measured patterns for these helices are illustrated by the pattern models of Figure 4 and also are shown by the dashed curves in Figure 5. In each case, the measured pattern is an average of the patterns measured for the vertically and horizontally-polarized components of the radiated electric field intensity. Calculated patterns, discussed later, are shown by the solid curves in Figure 5. Half-power beamwidths scaled from both the measured and calculated patterns of Figure 5 are compared with values obtained by formula (1) in the table.

Substantial agreement with the measured beamwidths in all cases, except for the 2-turn helix, is available from (1). Generally, this formula agrees well with measured values for helices with an axial length, nS , greater than about 3/4 wavelength.

At the center frequency $C = 1.0 \lambda$,

and for a pitch angle of 12.5°, (1) reduces** to

$$\beta = \frac{52}{\sqrt{0.22n}} \text{ degrees} \quad (2)$$

Solving (2) for the number of turns, n , we have

$$n = \frac{12,300}{\beta^2} \quad (4)$$

Thus, for example, if a half-power beamwidth (β) of 50° is desired at the center frequency, the number of turns required is 4.9.

Half-power beamwidths as given by (1) are illustrated graphically in Figure 6 as a function of the axial length of the helix, nS , and of the circumference, C , in free-space wavelengths. As an example, the beamwidth for a helix with an axial length of 2 wavelengths and circumference of 1 wavelength at the center frequency was found to be 37°. For $C = 1.2 \lambda$, near the high-frequency limit for the beam mode, it was found that the beamwidth was 28°; while for $C = 0.8 \lambda$, near the low

frequency limit, the beamwidth was 51°.

The number of turns, n , for the center frequency and a pitch angle of 12.5°, is also indicated in Figure 6 by the lower scale for the abscissa. Thus, for a 37° beamwidth at the center frequency, a 12.5° helix requires 9 turns.

If the shape of the main lobe of the radiation pattern is desired it can be drawn approximately as in Figure 3, with the aid of half-power points given by (1) and the beamwidth, β , between first nulls of the pattern as given by

$$\beta = \frac{115}{\frac{C}{\lambda} \sqrt{\frac{nS}{\lambda}}} \text{ degrees} \quad (5)$$

This procedure for calculating the pattern may be called a short method in contrast to a longer method discussed later.

Power Gain

A very simple approximate expression for the power gain of a helical beam antenna, with respect to an isotropic circularly-polarized source can be obtained by dividing the square of the beamwidth as expressed by (1) into the number of square degrees in a sphere (41,253). Thus,

$$\text{Gain} = 15 \left(\frac{C}{\lambda} \right)^2 \pi \frac{S}{\lambda} \quad (6)$$

or as a decibel ratio

$$\text{Gain} = 11.8 + 10 \log_{10} \left[\left(\frac{C}{\lambda} \right)^2 \pi \frac{S}{\lambda} \right] \text{db} \quad (7)$$

These formulas neglect the effect of minor lobes and the gains may in some cases be slightly high, but usually not by more than 1 or 2 db. The same restrictions apply to (6) and (7) as to (1).

At the center frequency ($C = 1.0 \lambda$) and for a pitch angle of 12.5°, (6) reduces*** to

$$\text{Gain} = 3.3 n \quad (8)$$

**In the more general case where $C = 1.0 \lambda$ but a , and hence S , is not specified, formula (1) reduces to

$$\beta = \frac{52}{\sqrt{A/\lambda}} \text{ degrees}, \quad (1)$$

where A = axial length = nS . By way of comparison with another form of end-fire antenna, Mueller and Tyrell² state that $\beta = \frac{60}{\sqrt{A/\lambda}}$ degrees for polyrod antennas where A is the length of the polyrod.

***In the more general case where $C = 1.0 \lambda$ but a , and hence S , is not specified, formula (5) reduces to

$$\text{Gain} = 15 \frac{A}{\lambda}, \quad (10)$$

where A = axial length = nS . By way of comparison with another form of end-fire antenna, Mueller and Tyrell² show that $\text{Gain} = 3 - \frac{\lambda}{A}$ for polyrod antennas where A is the length of the polyrod.

Turns (n)	2	4	6	8	10	
Axial lengths (nS)	0.42 λ	0.84 λ	1.26 λ	1.68 λ	2.10 λ	
Half-power beamwidths	Calculated by (1)	81°	58°	47°	41°	36°
Measured	67°	54°	45°	40°	34°	
From pattern calculated by (13) and (14)	70°	56°	46°	43°	38°	

Table I

$\alpha = 12.2^\circ$; $C = 0.98 \lambda$; $S = 0.21 \lambda$

Metallic Rectifier Banks, Designed for 50-Kw AM and FM Transmitters, Provide 5 Amperes at 11,500 Volts DC and 4 Amperes at 12,500 Volts DC in Modulator and Power Amplifier Supplies.

by N. B. THARP and C. K. HOOPER

Advisory Engineer

Design Engineer

Electronics and X-Ray Division
Westinghouse Electric Corporation

icle 46" high, 37" wide and 24" deep. This unit thus takes up about six square feet of floor space, and 24 cubic feet volume. These dimensions do not include the blower which requires a small additional space.

The characteristics of most metallic rectifiers change somewhat with time. In general, these changes involve both the forward and back resistance. Usually the forward resistance increases with time and the back resistance decreases with time, resulting in some drop in output voltage. However, in the case of the specially processed selenium, which is now used for high power dc supplies in our transmitters, the forward aging has been found to be quite small. Furthermore, the aging effect is usually complete after three or four years operation and no further significant change should take place. The back aging characteristics of this same selenium have been too small to be measured on the life tests taken to date.

Forward aging characteristics of an installation at KDKA are shown in Figure 1. It will be seen that the reduction in output voltage with time is about 1% in a year. Usually this slight change can be tolerated without requiring the use of any special voltage compensation.

As mentioned before, the high-power, high-voltage metallic rectifier uses many discs or cells in series. For example, in the supply for the AM-transmitter power amplifier, a polyphase rectifier is used having six legs or elements. Each of these elements has 318 cells or discs connected in series, making a total of 1,908 cells for the entire rectifier. This large number of cells has been found to contribute to the uniformity and reliability of the equipment. Any variations in the characteristics of the individual cell are effectively cancelled by the averaging effect of many cells.

In the event of trouble, the metallic rectifier has an inherent advantage. Any tendency toward failure will be indicated long in advance by reduced voltage or an increase in hum in the dc output. During normal shut-down periods, then, the suspected element can be checked and replaced if it shows abnormal forward or back resistance.

Metallic Rectifier Characteristics

The use of metallic rectifiers in the high voltage supplies of a broadcast transmitter offers many advantages. One major factor is the length of useful life. For all practical purposes, the metal rectifier is good for the life of the transmitter. While there is some reduction in output voltage in the first few years of operation, this can be compensated for, if desired, by taps on the high voltage transformer or by adjustment of the voltage regulator which is used on most quality transmitters. The possibility of an element actually failing is remote and even then, probably only a small segment would be affected.

The elimination of rectifier hash and telephone interference and the associated filters is a benefit that usually accompanies the use of the rectifiers.

The metallic rectifiers require no warm up time before application of high voltage. This eliminates the need for a rectifier filament time delay relay and the associated maintenance. Also, the transmitter can be returned to operate immediately following an interruption from a short duration power line failure, which again reduces the program interruption time.

Another important advantage of the metallic rectifier is its ability to with-

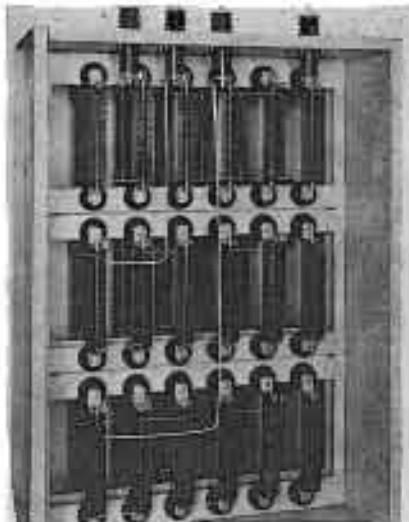


Figure 3

Selenium rectifier used in the modulator supply of a 50-kw AM transmitter. This rectifier supplies 5 amperes at 11,500 volts dc.

stand relatively high surges of inverse voltage without *flashing back*. Such inverse surges are dissipated in the back resistance of the rectifier without damage. Furthermore, temporary overloading of the nature likely to occur in a broadcast transmitter produces no harmful effect. Even prolonged overloading which would probably ruin a mercury vapor rectifier would only result in an increase in the aging effect with a slight drop in output volts in the case of the metal rectifier.

An additional benefit of these characteristics is the elimination of step-start apparatus for protecting the rectifier tubes. This saves the maintenance and possibility of trouble connected with the large and often used contactors required.

Not to be overlooked is the advantage the metallic rectifiers offer in providing flexibility in the physical arrangement of the transmitter and the station layout. Since the rectifiers are no longer critical components requiring frequent observation, they can now be placed in the power vault with other power equipment.

One must also consider, of course, the disadvantages associated with the use of metallic rectifiers and the effect in broadcast application. First, the metallic rectifier must be forced air-cooled for most efficient utilization of its capability. Fortunately, where it is used with an air-cooled transmitter receiving all its air from a single source, there is no problem.

Another unwanted characteristic is the regulation introduced under large

(Continued on page 27)

¹Westinghouse type 30 HG-2.

²Westinghouse EM-52.

South Australian Police

FM NETWORK



Figure 3

Remote equipment hut at Mount Osmond (1,250 feet above sea level), overlooking the city of Adelaide.



Figure 4

Goss operating equipment at a regional station in Mount Gambier. The microphone on the desk is connected to a wire reader.

Figure 5
Control panel in a car.



System, Operating on 72.5 Mc, Employs Basic 250-Watt Transmitter Located in Flat Plains of Adelaide, Australia, With 25-Watt Remote Station 1,250 Feet Above Sea Level, and 10-Watt Mobile Units.

by R. W. GOSS

Chief Engineer, VLSAP

FOR MANY YEARS every State in Australia, except South Australia, has had a very efficient radio branch. When the war was in progress, the very many advantages of police radio were made apparent and the South Australian Police Department decided that they too should have a modern radio branch.

AM or FM

The most difficult decision which had to be made was the type of system to use; AM which had given the other states efficient service for so many years, or FM which had become very popular in other countries, but as yet remained unproved in Australia.

With some little anxiety we specified FM and caused much speculation as to its success.

The Site

The City of Adelaide nestles on a flat plain bordered on one side by the sea and on the other by mountains. According to the text books this was an ideal layout, in fact a city whose destiny practically demanded FM.

After twelve months' operation our faith in FM has repaid us generously by proving a very definite superiority over AM.

The service area averages 25-30 miles radius from the central transmit-

ter and signals are clear, free from all noise and with ample strength.

Specification Factors

When writing the specifications there were three major points to consider: (1) Number and power of transmitters; (2) number of receivers; and (3) power of mobile transmitters.

With such a flat area to cover, one transmitter of 250 watts in the city and another of 25 watts situated 1,250' above sea level in the hills were deemed sufficient to give ample service.

Dual Receiver Setup

Similarly two receivers, one with each transmitter, were considered satisfactory. The amount of power for the mobile transmitter was fixed at 25 watts in accordance with most overseas standards. With this came heavy battery drain, in the region of 32 amps while transmitting. Recently the power was reduced to 10 watts using vibrators, without any material reduction in range. Maintenance has been reduced considerably. Previously batteries could not be charged off the car generator and consequently had to be changed after every patrol. Now the radio battery which is still independent

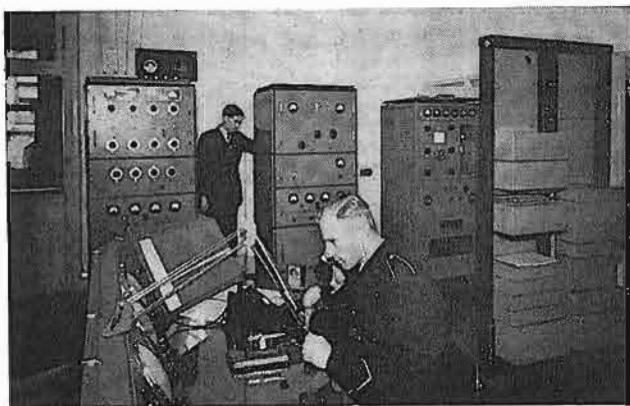


Figure 1

General view of the transmitter used at VL5AP. At left is a four channel *cw* transmitter and in the center is the FM transmitter being examined by R. W. Goss. Transmitter on right is a radio-telephone unit used for the country regional stations.

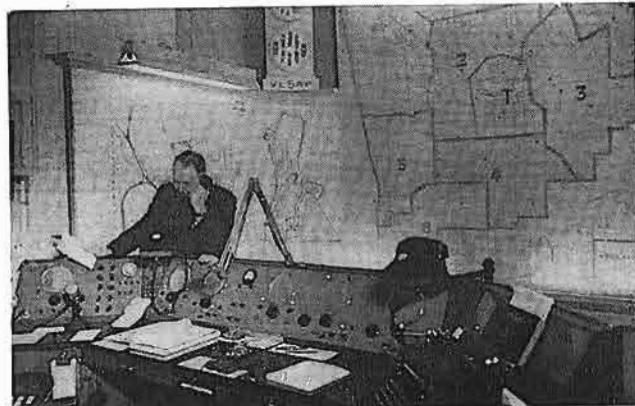


Figure 2

Panels of the console: Telephone dial on the left controls the indicator lights on the map shown in the rear; loudspeaker and associated controls serve the country regional stations, intercom system between police officials and console personnel, local and remote FM receivers, monitor for *cw* interstate transmitter and interstate *cw* receiver. Beneath the clock appears an indicator which reveals the zones in which the cars are operating.

of the car battery can be charged efficiently in the vehicle.

The Central and Remote Transmitter

The main 250-watt transmitter, crystal controlled on 72.5 mc, consists of an exciter unit of 25 watts, identical with a mobile transmitter, driving a power amplifier of 250 watts using two 8001s in parallel. The antenna is a quarter-wave ground plane atop a tower 120' from ground and coupled by coax cables.

1,000-Cycle Oscillator

During non-transmission periods the loudspeakers in the cars were so quiet it was found necessary to incorporate a 1,000-cycle note oscillator. Every thirty seconds this note is transmitted to notify the men that their equipment is operating correctly.

Automatic Operation

This is an automatic operation and can be controlled for length of *pip* and time between each *pip*. A small lamp indicates to the operator that the note is on the air. A small bank of relays switch on the transmitter *pip* the oscillator and switch off the transmitter. The operator can select either the central unit, the remote unit or both, to be energized by switching from the console. This applies to either speech or tone.

Double-Conversion Receivers

The receivers are double conversion type incorporating automatic squelch circuits and, apart from the power sup-

ply, are identical with those used in the mobile units.

Noise Voltage Control

Noise voltage is picked off the discriminator, amplified, rectified and applied as bias to the first audio stage, effectively silencing it.

Blocking Action

The grid of the squelch tube, a 6SQ7, is connected back to the limiter stage so that when a signal is received it also acts as bias on the squelch tube, affording a block and thus allowing the receiver to operate normally.

Landlines connect the remote transmitter and receiver with the console and complete control is achieved from the console.

Remote Site

The remote equipment is housed in a concrete building on a hill top six miles from the city. Being somewhat isolated precautions were necessary in case of power failure. Should the power fail, all the equipment can be automatically changed over to battery operation. A small oscillator is placed into operation and transmits a pulse over the landline to the console lighting a small warning lamp every ten seconds. When the power is restored the equipment is automatically switched back to line operation, the oscillator stops and a battery charger brings the battery back to full charge.

This transmitter serves the hills, roads, extreme ranges on the plains,

and also a launch which is anchored at Port Adelaide. This launch serves the beaches along the gulf.

Combined Operation

Both the central transmitter and the remote system can be used together if necessary with very little or no distinction, the stronger signal capturing the receiver.

The Mobile Equipment

In an attempt to standardize spares and simplify maintenance the mobile transmitter was designed as a duplicate of the main transmitter's exciter unit. Initially of 25 watts, power has been now reduced to 10 watts. The maximum range obtained with 25 watts was 85 miles, excellent two-way communication being maintained right up to that range.

The receiver is mounted on one chassis, with its own power supply which is also used for the transmitter, except for the final stage high power. The transmitter is on another chassis, together with the power supply for the final stage which is an 815.

Transmitter Power Feed

High power for the transmitter is applied through the medium of a switch in the telephone handset. If prisoners are being carried in the vehicle and confidential information is being aired the loudspeaker (mounted under the dash) may be switched off and the handset used as a normal telephone.

Battery drain of the receiver is 7 amps and the total drain on 25 watts

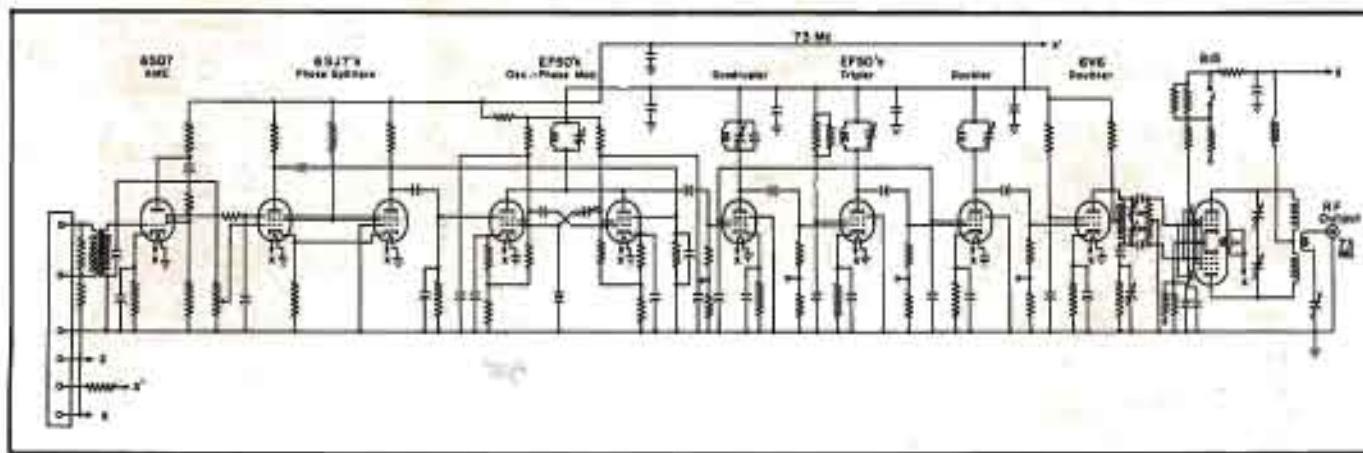


Figure 6
Circuit diagram of the mobile FM transmitter and exciter stage for the headquarters transmitter.

was 32 amps and on 10 watts, 22 amps.

The Interstate Network

In the control room there is also an interstate car transmitter of 300 watts. This is quite standard using 807's in the first stages and two 813's in parallel in the final. Four crystal-controlled channels are available and can be selected by throwing a switch. The antennas are half wave Y match, suspended between steel towers constructed above the building.

Network Receivers

The receivers used on this network are crystal locked and installed in the remote hut at Mount Osmond with the FM gear. Circuits are quite standard using two rf and two if stages. Both transmitters and receiver will cover from 2 to 20 mc.

One landline pair, used for each receiver, carries the pulses for several

different functions as well as the audio down to the console speakers.

The receivers may be switched on and off; the rf gain raised and lowered and the bfo note changed over four positions.

Audio Oscillator

In the console is a small audio oscillator which feeds a signal up the line to the receiver where it is amplified, filtered, rectified and then used as bias on the rf and if stages.

When the frequency of the oscillator is resonant with the tuned filter in the receiver the voltage is maximum, as is the bias on the receiver.

As the frequency moves away from resonance (by moving the control on the console) the bias falls off and thus the rf gain of the receiver is effectively

controlled by adjusting the oscillator frequency.

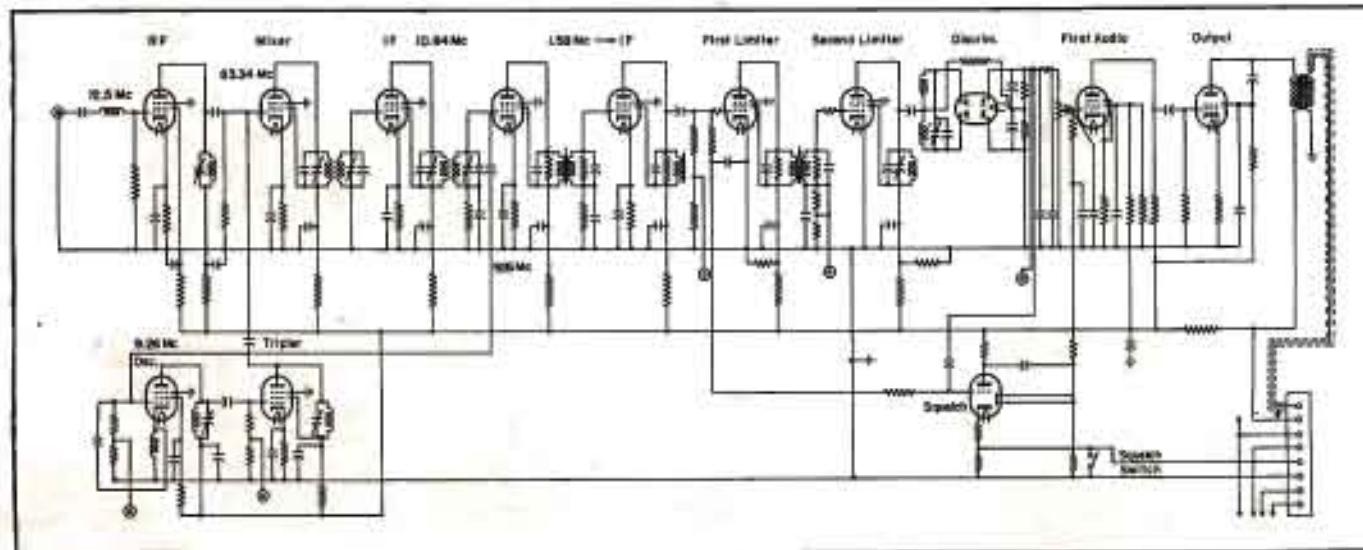
BFO Note Control

The bfo note is varied by means of a bank of relays in a ring circuit, each connecting a different size capacity across the oscillator when it is closed. The relays are operated by pulses sent up the line from the console.

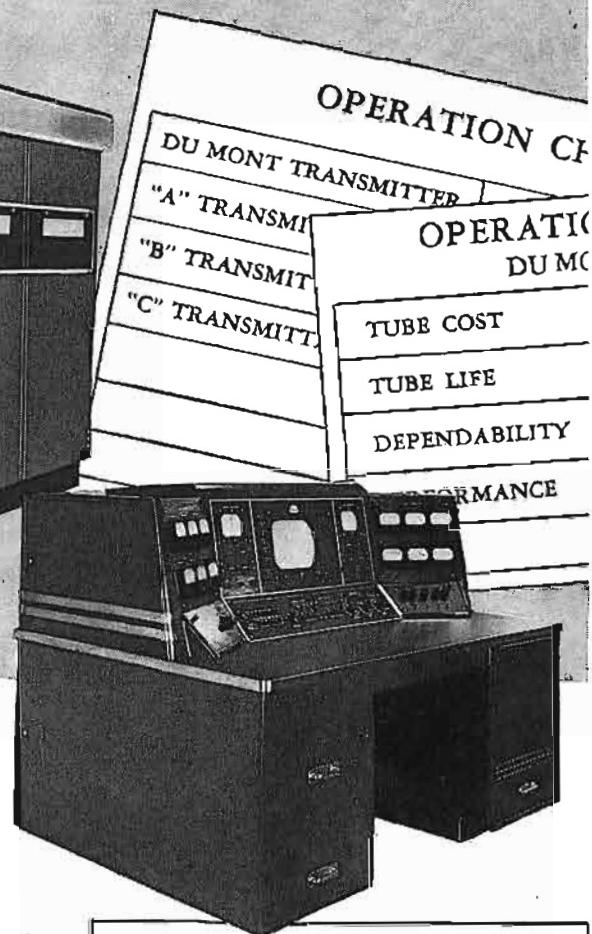
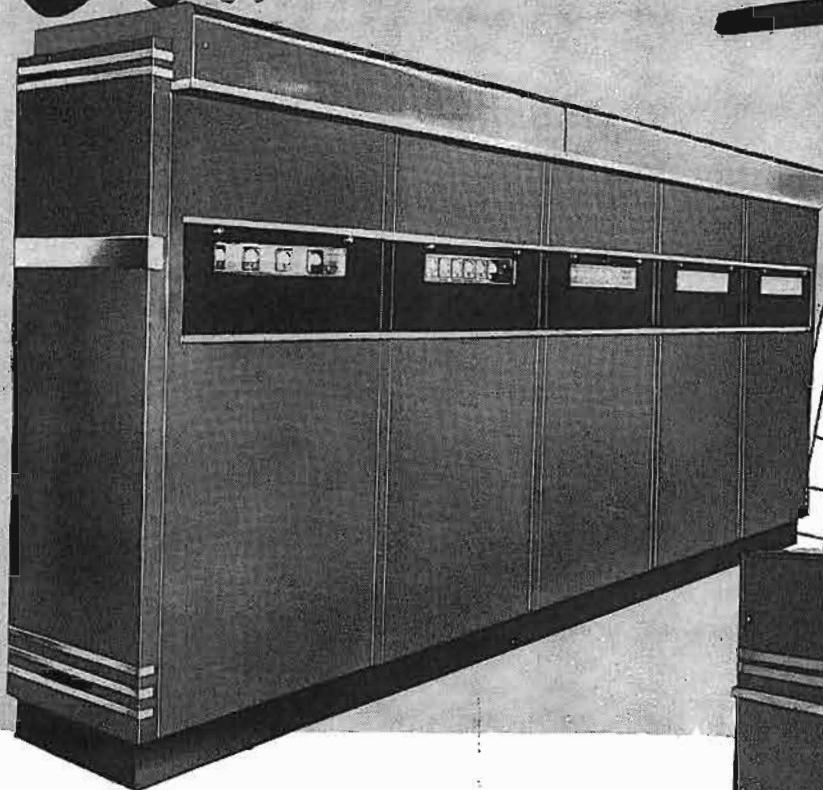
CW Transmitter

The cw transmitter has a built-in monitor, which besides providing an audible check of the message, also indicates the operating condition of the gear. The monitor consists of an 807 audio oscillator which draws its screen voltage from the carrier. Approximately 1,000 volts of rf are fed to a small coil, which is rectified and fed to the screen. Thus the monitor is an indication of the quality of the transmitted signal.

Figure 7
Circuit of the mobile receiver.



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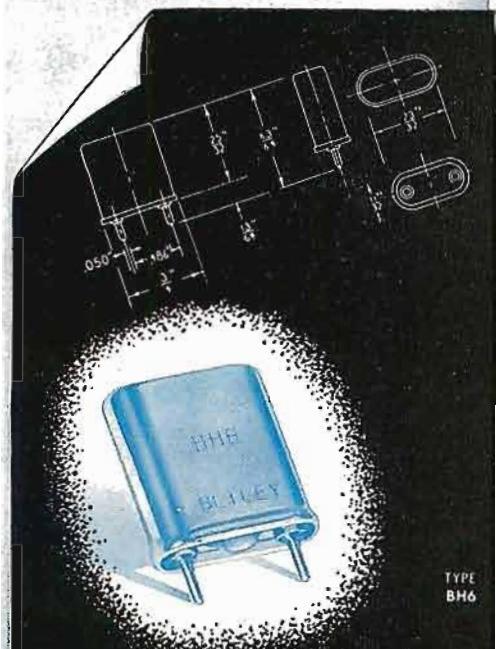
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AUDIOGRAPH PORTABLE TAPE RECORDER

A tape recorder, which is said to feature constant-current output with preemphasis equalization and head replacement without response variation, has been announced by Audiograph Co., 1412 El Camino Real, San Carlos, Calif. Uses seven-and-one-half-inch-per-second tape speed which is said to provide ± 2 db response from 50 to 10,000 cps.

Unit is housed in two carrying cases. Five separate amplifiers, tape-transport mechanism, and electrical interlocking controls are in one unit; power supplies, monitor speaker, and storage space for accessories and tapes are in the other. There are two input-line or microphone amplifiers with impedance-change switches; recording amplifier; line amplifier; monitoring amplifier; and playback amplifier. The recording amplifier is arranged with a plug-in tape equalizer. Equalizer and synchronous motor switch are provided for dual-speed operation. A NAB standard illuminated $\mu\mu$ meter is used.

Mechanical unit holds 1,200' of tape on standard reels, drives it by capstan and retractable pinch wheel. Mechanical bias for tape takeup and feedoff is provided through a fluid-drive device which causes the tape reels to rotate in opposite directions to prevent tape overthrow. Breaking and fast-forward and reverse are controlled through magnetic clutches.



McLAUGHLIN HETERODYNE ELIMINATOR

A heterodyne eliminator, type MCL-4, has been announced by James L. A. McLaughlin, 429 Pearl Street, La Jolla, Calif.

G.E. TV FILM CAMERA

A TV film camera, model 4PC2B2, has been announced by the G. E. transmitter division.

Features a 6-tube preamp which has three peaking circuits, hermetically sealed plug-in type electrolytes, and a polarity reversal switch for both positive and negative film.

Camera has prefocused, independently adjustable edge lights which are said to reduce edge flare and eliminate undesirable reflections. Camera also has a variable coupling yoke, the adjustment of which is said to permit the picture raster to have very straight edges and angles.

W. L. Shepard, G.E. TV engineer, studying the video preamplifier in a film camera.



ERC FLAT CERAMIC CAPACITORS

Flat ceramic capacitors, Hi Q Flats, which can be produced in an unlimited range of capacities, have been announced by Electrical Reactance Corporation, Franklinville, N. Y. The number of capacities on a plate is said to be limited only by the K of the material and the physical size of the unit.



RCA TV STUDIO REMOTE CONTROL EQUIPMENT

Television studio remote control panels designed for mounting in the upper compartment of studio control console housings (RCA MI-26266) have been announced by the RCA Engineering Products Department. Included are panels for remote control of a monoscope camera, power supplies, relay receiver, sync generator, and stabilizing amplifier.

The new panels are 11" wide by 2 1/2" high.



HEWLETT-PACKARD WIDE-BAND AMPLIFIER

A wide-band amplifier, 460A, with a pulse rise time of .003 microsecond and a gain of 20 db, has been announced by Hewlett-Packard Co., 395 Page Mill Road, Palo Alto, Calif.

Designed for use with HP 410A vacuum tube voltmeter, and in this connection will increase voltmeter sensitivity 10 times at frequencies up to 200 mc.

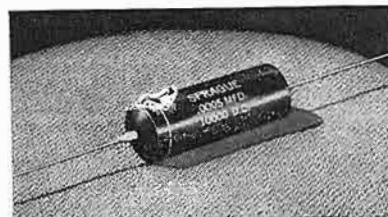
Instrument said to give optimum performance through impedance of 200 ohms.

SPRAGUE 10,000 VOLT MOLDED TUBULAR CAPACITORS

Molded tubular capacitors, type 84P Telecaps, in ratings as high as 10,000 volts dc, have been introduced by the Sprague Electric Co., North Adams, Mass.

Tubulars are said to be molded in non-flammable phenolic that is highly resistant to heat and moisture. An exclusive design is said to permit mineral oil impregnation of the capacitor section after the phenolic casing has been molded around it. The complete assembly is then solder-sealed in the same manner as metal enclosed oil-paper capacitors.

Bulletin 214 provides complete details.



A $33\frac{1}{3}$ -45 RPM Frequency Conversion Supply

Oscillator, Providing Change in Frequency to Turntable, Permits Use of $33\frac{1}{3}$ Turntable for 45 RPM Records.

by F. KEITH BROWN

Chief Engineer
WGGA, Gainesville, Georgia

THE ADVENT of 45 rpm recording has posed a number of problems for the broadcast engineer as well as home users. While several manufacturers are in production with 45 rpm turntables, most of units are for home use and have entirely too much rumble and wow for broadcast standards.

It would be most desirable if present broadcast transcription turntables could be used for all records; 45, $33\frac{1}{3}$ micro-groove *lp*, standard $33\frac{1}{3}$ transcriptions, and 78 rpm records. This might be accomplished on some turntables with new idler wheels, but they are usually not readily changed. The planetary drive turntables¹ require elaborate mechanical gearing beyond the reach of the broadcast engineer.

In probing the problem, a solution, requiring no changes in the turntable mechanism itself, was found by changing the frequency of power to the turntable motor. A 60-cycle $33\frac{1}{3}$ rpm turntable, when operated on 81-cycle power, was found to rotate at 45 rpm. It was also found possible to operate a 78-rpm 60-cycle motor with 34.6-cycle current for 45 rpm, but the danger of overheating the motor prevailed, a condition that was not present with 81-cycle current. Since nearly all broadcast turntables are powered with synchronous motors, a stable oscillator was tried and found capable of insuring low wow and speed variation with no change in inherent rumble of the turntable.

In the circuit a conventional resistance-capacity tuned 6SJ7 oscillator stabilized by degenerative feedback was included, with a 6V6 isolation amplifier, 6SN7 phase inverter and push-pull-parallel 6L6 power amplifier.

A $10 \times 14 \times 3$ chassis was used with the power supply mounted on a separate chassis. Quite a few changes can be made in the circuit to accommodate

parts on hand, since the only parts which control the frequency or stability to any extent are C_1 , C_2 , C_3 and R_1 , R_2 and R_3 . Incidentally, it is important that the rotor of C_2 be insulated from the chassis, since it is connected to the grid of the oscillator. Since C_1 is used to balance out the difference in capacity to ground in one side of C_2 , its value will be different for individual C_2 's. If the value of C_1 is too small, the 6SJ7 may not oscillate stably. If the oscillator will not operate at 81 cycles with the capacitor at hand, R_1 and R_2 can be changed to suit. Capacitors with less capacity will require higher than 10 megohms resistance and vice versa.

After several months operation our unit has not required any readjustment of frequency. A power transformer was found to operate very well as the output transformer. The high voltage winding must, of course, have sufficient current carrying capacity to handle the 61.6s.

Our turntables¹ require 35 watts operating power with somewhat higher starting power, and therefore at 81

¹RCA 70C2

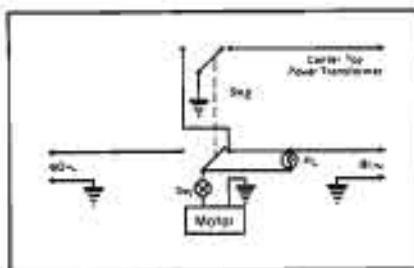


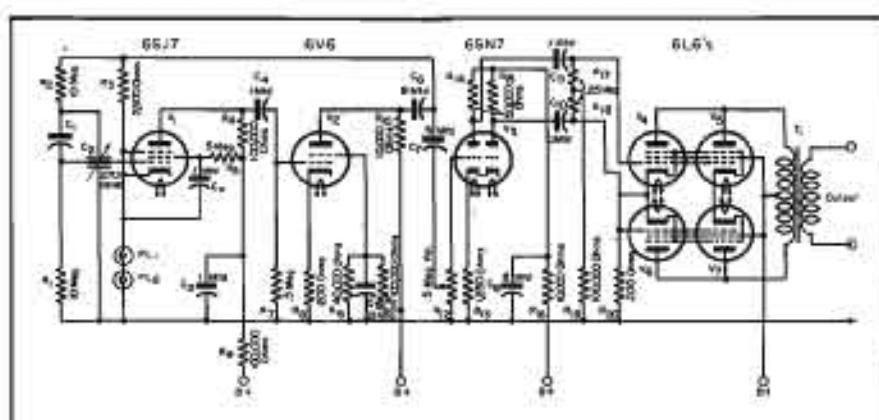
Figure 1
Block diagram illustrating frequency-change layout.

cycles the motor was found to require 5 to 10 volts above the 60-cycle rating for equal torque. We had to adjust R_3 for proper 6L6 grid bias (18 to 22 volts) with plate voltage used; R_1 varies the output voltage.

As with all high power amplifiers it is important that the unit should not be operated without load, or the output transformer insulation may break down. We used a stepping relay to change from 60 to 81-cycle operation, with one pair of contacts to open the centertap of the plate power supply, so that the 81-cycle supply would be off when not in use. Incidentally, a toggle switch will operate as well or better but we had a relay and no switch. A 115-v pilot lamp was set up to serve a dual function: loading of the 81-cycle supply, should the turntable switch be opened with the changeover switch on 81 cycles, and indication of the kind of power being supplied to the turntable motor. With the power supply we had

(Continued on page 33)

Figure 2
Oscillator used at WGGA to provide 81-cycle power to rotate a $33\frac{1}{3}$ turntable at 45 rpm.



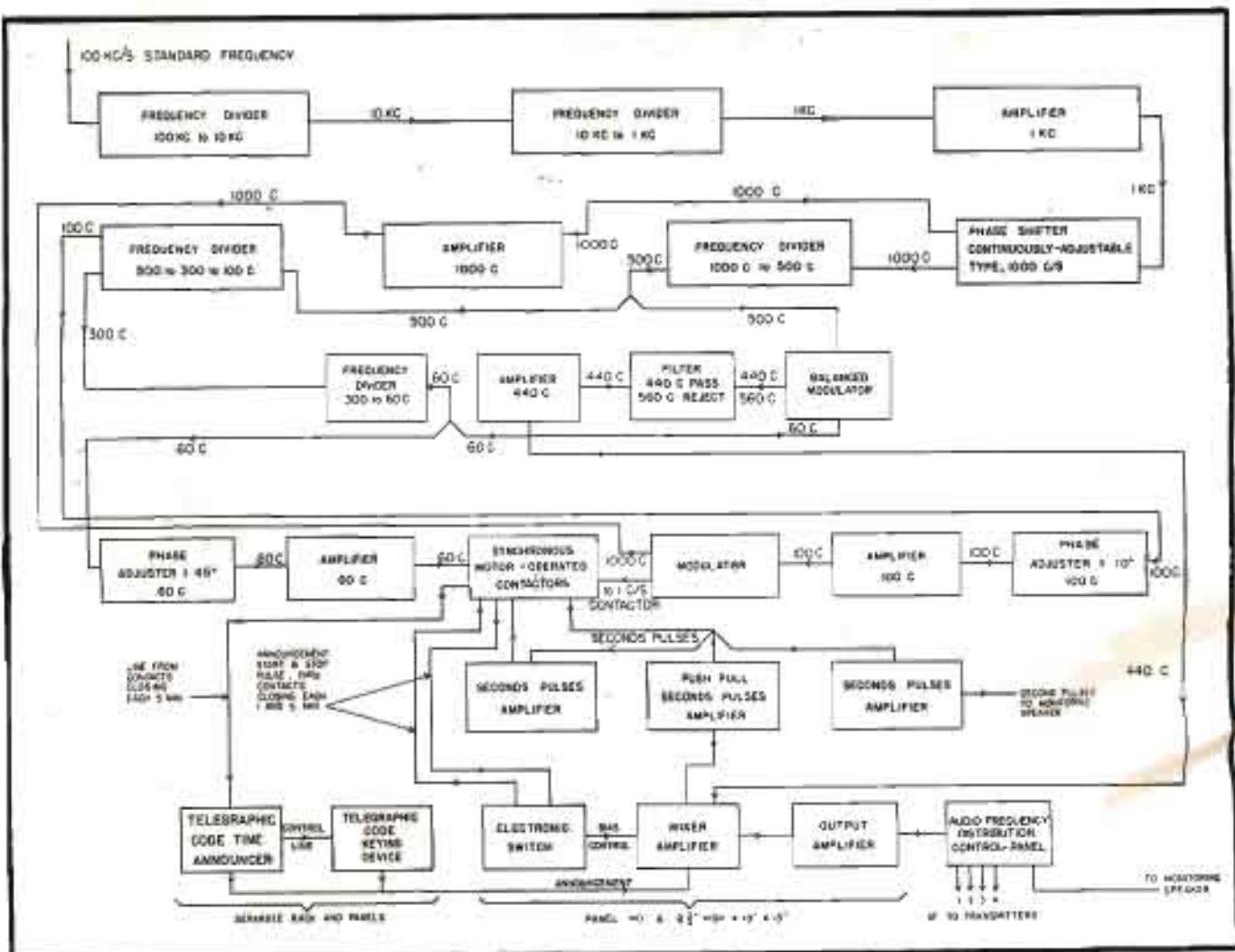


Figure 4
Block schematic of equipment used for composition of standard audio frequencies and time intervals and automatic content of time and telegraphic code announcements.

frequency-time standard of great accuracy and stability to control the transmissions. Quartz-crystal controlled oscillators are the best yet available for this purpose. These oscillators should be provided in triplicate to insure accuracy of the broadcasts and to enable local comparison between the different oscillators to determine more easily which particular oscillator varied in drift rate and by how much. To insure the continuity of the broadcasts, provision must be made for duplicate installations of radio- and audio-frequency control equipment. These separate sets must be periodically adjusted to maintain very close agreement with each other. Upon failure of any unit in the chain from piezo oscillator to control output, the alternate set can be used to control the broadcasts.

Certain portions of the submultiple equipment as well as the piezo oscillators must be kept operating during periods of power failure. For this

purpose a set of plate and filament storage batteries and the necessary float chargers must be provided for each control channel.

To facilitate the installation of WWVH, a complete set of frequency and time control equipment from WWV was revised and reinstalled in Hawaii. Revision consisted of providing rack-mounted piezo oscillators and relocation of some units.

The frequency-time standard and monitoring racks now used at WWVH contain one rack with a 100-kc frequency standard with its associated amplifier to furnish two isolated 100-kc outputs. One of these outputs is used to furnish excitation for the rf multiplier equipment and the other to control the af derivation equipment for the production of time signals and modulation frequencies.

Another rack contains (a) telegraphic code time announcer for giving the correct time every five minutes in GMT, by means of telegraphic

code, starting on the 35th second of every announcement interval; (b) keying device for identification of the station (unit keys the call letters WWVH twice in telegraphic code 5 seconds after the completion of the time announcement); (c) frequency multiplier consisting of a single-stage 100-kc amplifier and two push-pull quintupler stages; (d) rf distribution amplifier using four 807s with the grids driven in parallel but with individual isolated plate output circuits delivering two watts at 2500 kc to 70-ohm coaxial lines for transmitter excitation; and (e) 100-kc piezo oscillator, its associated amplifier, a power supply voltage filter and voltage regulator unit.

As 2.5 mc is the lowest standard frequency that may be transmitted, it is economical to multiply the control frequency to this value in one unit, thus materially reducing the number of multiplier stages required in the individual transmitters. The 100-2500

kc multiplier output is approximately one watt into a 70-ohm line. Unwanted harmonics are down 50 db and modulation products are attenuated by more than 70 db. Type 807 tubes operated very conservatively were used in the balanced quintupler stages to insure reliability.

A third rack contains the following equipment, starting at the top:

- (a) A second telegraphic code time announcer unit, which operates in conjunction with the one on top of the adjacent rack, and acts as a check unit to remove all time signals from the air if either of the two units falls out of step with the other.
- (b) Frequency divider unit.
- (c) Phase shifter and frequency divider.
- (d) Divider - multiplier - modulator unit.
- (e) Monitoring panel for aurally checking the audio signals used to modulate the transmitters.
- (f) Seconds pulse generator and time interval selector unit.
- (g) Mixer amplifier unit.
- (h) Individual gain controls for remotely adjusting the modulation level of the transmitters.
- (i) Regulated power supply for mixer amplifier unit.

All but the top unit on this rack are used in derivation of the standard audio frequencies, standard-time and time-interval signals occurring at intervals of 1, 4, 5, 9, 10, etc., minutes.

The dividers employ tubes operating as class A amplifiers with voltages from tuned circuits in the plate reflexed and mixed with the input frequency in a balanced modulator circuit. The modulator type of divider has a distinct advantage in that it does not self-oscillate but requires an externally supplied input voltage of the proper frequency before any output voltage can be obtained.

The second unit on this rack contains two 10-to-1 frequency dividers which furnish a 1-kc output from a 100-kc input from the frequency standard. A 1-kc amplifier is also incorporated in this unit.

The large dial at the left of the third unit is on the rotor shaft of a selsyn unit operating at 1000 cycles. By manually turning the rotor, cycles can be added to or subtracted from the input frequency. This phase shifter permits the time signals generated in a later unit to be advanced or retarded and set in exact agreement with any time signal. With the unit it is possible to set the seconds pulses from two similar divider chains in agreement within ± 2 microseconds using an ordinary 'scope. The frequency divider operating from the

output of the phase shifter furnishes output voltages at 500, 300, and 100 cycles.

The frequency divider in the fourth unit, excited by 300 cps has an output at 60 cps. In a balanced modulator supplied with 60 and 500 cps the output is 440 and 560 cps. This output is passed through a filter network which rejects the 560 cps signal and passes 440 cps, the standard of musical pitch corresponding to A above middle C.

The 1000-cycle signal is used to excite a frequency multiplier which has an output frequency of 4000 cycles. A mixer unit is provided for furnishing a tone consisting of equal amplitudes of 440 and 4000 cycles for modulating the transmitters.

The 100- and 1000-cycle signals from previous units are mixed in a balanced modulator circuit and a series of pulses, each consisting of 5 cycles of 1000 cycles, is generated. To produce good sine-wave pulses, a phase shifter is provided in the 100-cycle circuit to adjust the phase so that both voltages are at zero simultaneously.

The 60 cycles from the previous unit is converted into 2-phase 60 cycles which is amplified to drive a self-starting synchronous motor having an output shaft speed of 1-rps. A set of contacts operated by a cam on the 1-rps shaft is closed each revolution for a period of about 10 milliseconds. This mechanical gate allows one pulse per second from the 100 pulses per second to pass into an external circuit.

By reduction gears the clock motor also drives cam shafts which have speeds of 1 rpm and 12 rph. Exactly on the proper minute of the five-minute interval in the hour and on the proper second of the minute these cams close switches and channel a seconds pulse into one branch of an electronic switch. This switch operates, and in so doing puts cut-off bias on the tone branch of the mixer amplifier unit and establishes normal operating bias on the announcement branch. Whatever intelligence is desired is passed through the announcement branch to modulate the transmitters.

Exactly one minute later on the hour and each five minute interval thereafter another seconds pulse is channeled into the electronic switch where it operates to put cut-off bias on the announcements branch of the mixer and to establish normal operating bias on the tone branch.

From the foregoing it can be seen that the mechanical contacts function only as gates to channel the seconds pulses into the proper circuits. The

seconds pulse derived from the 100-kc standard is the determining element in the accuracy of the time intervals.

Monitoring Equipment

In rack 4 of the WWVH set up are the remote control equipment and monitoring recorder, as well as the equipment for monitoring WWV, to maintain the accuracy of the frequency and time signals of WWVH.

The top panel on this rack contains the relays for synchronizing the operation of the WWVH and the ionosphere sounding transmitters.

On the second panel is a manually operated remote control unit for the WWVH transmitters. Push-button type switches shut off the transmitters completely. Rotary type switches permit the removal of the plate voltages of the rf modulator or rectifier units as desired.

A time recorder for monitoring the automatic features of the installation is mounted on the third panel.

Other equipment on this rack is used for maintaining the WWVH oscillators in agreement with the WWV transmissions.

The ionosphere sounding transmitter operates on the hour and half-hour and in one-minute sweeps through the range 2.2 to 16 mc. Supplementary manual observations are required when the vertical-incidence critical frequency exceeds 16 mc. Some means had to be provided for synchronizing the two sets of equipment as the high fields from WWVH signals caused unsatisfactory records from the sensitive automatic ionosphere equipment. This was accomplished by means of two cam-operated switches on the clock unit operated from the frequency standard. One switch is closed for a very short period of time to send a starting pulse to the sounding transmitter. The transmitter automatically shuts off after completing the sweep. Coincident with the above, a long-period cam operates a switch to shut down the WWVH transmitters. These transmitters remain off for 4 minutes and 20 seconds to permit manual ionosphere observations if required. The interval of 4 minutes and 20 seconds is the maximum amount of time that will permit WWVH transmitters to mark accurately the hour and 30-minute intervals before shutting down and still permit them to return to the air in time to give the telegraphic code announcement for the 5- and 35-minute intervals.

The recorder in the third panel of the rack is equipped with 20 relay-operated

(Continued on page 32)

A Cathode-Ray Tube

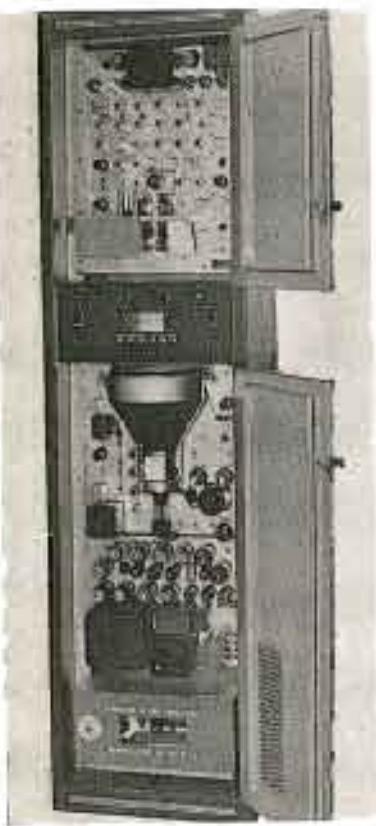


Figure 1

Front view of the video scanner. Picture tube is mounted on chassis containing deflection, focusing and blanking circuits. A high voltage ac transformer supplying 20 kv to the picture tube is located in the bottom of this unit. The low voltage supply, second from the bottom, provides regulated +250 and +350 voltages to the scanning and picture generator.

SCANNING A SUBJECT with a spot of light for the purpose of producing an electrical signal corresponding at each instant to the density of the subject was used effectively by early workers in television. And today this long-recognized principle still serves as the basis of design of TV photographic transparency¹ pickup equipment.

Recently it was found possible to build a scanner utilizing a ten-inch short persistence crt as the source of the flying spot of light, with the tube mounted on a chassis containing deflection, focussing and blanking circuits. Tests showed that light from the raster could be focussed on a slide by an objective lens (mounted on the top chassis) and light passing through the slide could be projected by a condenser lens onto the cathode surface of an electron-multiplication phototube. The resulting video signal thus could be amplified by circuits in the picture generator (top chassis) and modified by frequency compensating circuits to correct for crt persistence. Non-linear circuits were used to pre-distort in compensation for gamma characteristics of picture reproducing devices.

The scanning generator was designed so that the incoming horizontal and vertical RMA driving pulses would be clipped by amplifiers to insure clean signals. The differentiated leading edges of each were used to generate the sawtooth waveforms supplied to the deflection amplifiers. Straightforward circuitry including a 6AS7G damping tube in the horizontal circuit was found to yield good linearity. Measured by RMA methods, the displacement of a point from its true posi-

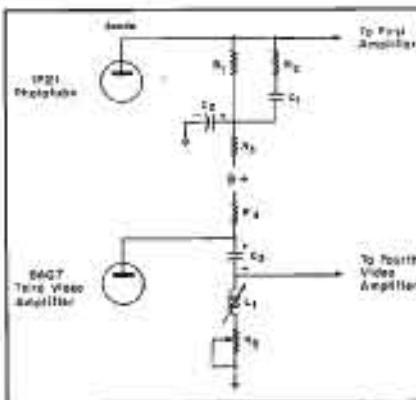


Figure 3

Frequency correction circuits. These two networks are used to provide compensation for a 500-line picture in the horizontal direction.

tion on the raster was found to be limited to about 1% of the picture height. Two sections of a 12AT7 were used to clip and amplify standard blanking signals for extinguishing the scanning spot during retrace periods. A pulse rectifier was included to apply a positive voltage to a sweep failure protection tube, causing plate current in that tube to energize a relay on which contacts close the cathode circuit of the crt only when both horizontal and vertical deflection voltages appearing across the secondaries of their respective transformers are normal.

A 6AG7 was connected in pentode fashion so that plate current would flow through the focus coil, and thus variations in coil resistance with temperature change could cause no defo-

Figure 4

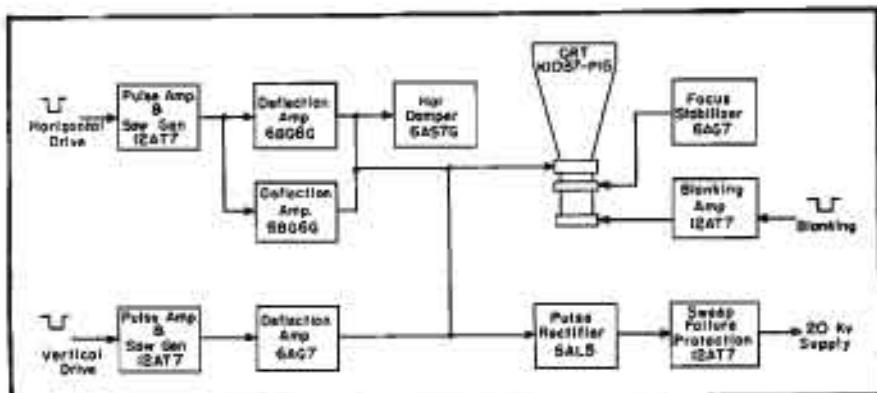
The video gain and blanking clipper pedestal controls illustrated in this view are normally used only when changing slides, although in uniformly prepared positive slides no adjustment has been found necessary. When using negative slides, the gamma corrector tends to emphasize density variation by its non-linearity and the problem of uniformity is greater in this case. Such variations are not a function of picture content, but only differences in density of the slides.



Figure 2

Block diagram of the deflection circuits.

¹Scientific, Ballard and Schroeder, An Experimental Simultaneous Color Televising System, Part II, IRE, September, 1947.
*Du Mont K 1037-P15



tion of time interval, to determine the oscillator frequency, the number of oscillations in a definite interval of time must be known. Assuming that the rate of drift of the oscillator has been uniform throughout the period under consideration, the average frequency for the period is the same as the instantaneous frequency for the middle of the period. The latter method is the one normally used in maintaining the WWVH frequencies in agreement with WWV.

After obtaining agreement between the local and received pulses the phase shifter is advanced 27 milliseconds before transmissions are resumed. This 27-milliseconds is the average transit-time for the Washington-to-Maui path.

Frequency Conversion

(Continued from page 19)

on hand the voltage regulation of the 81-cycle current was rather poor, resulting in sluggish starting of the motor. Therefore, we found it necessary to start the motor with 60-cycle power and then switch to 81 cycles. Our disc jockeys have had no difficulty in operating the system in this manner, simply holding the record until 45 rpm is reached, about one revolution after switchover.

To accommodate the 45-rpm records, the large center hole in the records was provided by a drilled bakelite disc.² Our pickup arm,³ with a filter transformer⁴ with output impedances of 250, 150, and 37.5 ohms, was mounted 14" to the left of the regular pickup arm so that it would not interfere with the playing of regular records and transcriptions.

²Available from Webster. ³Astatic FLT-33. ⁴Astatic FT.

Video Scanner

(Continued from page 25)

other unit of a system. The switch, located on the picture generator chassis, can be paralleled by a remotely located switch.

Picture output amplitude can be adjusted by varying the voltage applied to the dynode stages of the phototube.

Color Slides

It was found possible to use color slides in the scanner. The signal-to-

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This great, new book explains RADAR from basic principles to the details of equipment design. General descriptions of various radar systems are followed by complete accounts of every step in the analysis and design of magnetrons, pulse modulator tubes, receivers, oscillators, rectifiers, antennas, switches, and other components of radar systems.

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noise ratio was found to be slightly poorer than when good black and white slides were used because of the greater average density of the color slides.

Credits

Credit is due many members of our labs who participated in the design and construction of the scanner: The research division for the development of the crt; A. J. Baracket who directed initial development of the commercial equipment and A. L. Olson, who was responsible for scanning generator and slide changer designs.

KAY ELECTRIC INSTRUMENTS

Two instruments, the *Mega-Pix* and the *Mega-Node, Sr.*, have been announced by Kay Electric Co., Pine Brook, N. J.

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Helical Antennas

(Continued from page 9)

tory approximation by the following method.

Assuming a uniform traveling wave on the helix, the pattern of the radiation field of a helical beam antenna can be calculated^{6,7} as the product of the single-turn pattern and the pattern of an array of isotropic point sources, each source representing one turn of the helix. The assumption of a uniform traveling wave is a good one if the helix has at least a few turns. The pattern can be expressed as a function of the angle Φ with respect to the helix axis; Figure 8. Assuming that the phase velocity of wave propagation on the helix corresponds to the maximum directivity condition, the radiation field pattern, V_1 , is given for values of Φ between $\pm 90^\circ$ by

$$V = \left[\sin\left(\frac{90^\circ}{n}\right) \right] \left[\frac{\sin \frac{n\Phi}{2}}{\sin \frac{\Phi}{2}} \right] [\cos \Phi] \quad (13)$$

The first factor normalizes the pattern, that is, makes the maximum value equal to unity. The second factor gives the array pattern where*****

$$\Psi = 360^\circ \left[\frac{S}{\lambda} - (1 - \cos \Phi) + \frac{1}{2\pi} \right] \quad (14)$$

The third factor [$\cos \Phi$] represents the single-turn pattern. The vertically- and horizontally-polarized components of the radiation field of the single turn may actually differ considerably from this and also from each other.⁸ However, if the helix has at least a few turns, the

*****This relation is obtained by substituting (14) in (8) in reference (3) and simplifying.

array factor is dominant and the single-turn pattern can be taken equal to $\cos \Phi$ as a satisfactory approximation for many engineering applications. This results in a very substantial simplification in the pattern calculation.

Thus, (13) gives the pattern of the radiation field of the helix to a good approximation for any polarization provided only that the number of turns is not too small; say, not less than 2. For example, patterns calculated by (13) and (14) for 12.2⁶ helices with nearly 1-wavelength circumference ($C = 0.98 \lambda$) and of 2, 4, 6, 8 and 10 turns are illustrated in Figure 5 by the solid curves. For comparison, the measured patterns are indicated by the dashed curves. In each case, the measured pattern is an average of the patterns measured for the vertically and horizontally-polarized components of the radiated electric field intensity.

The pattern of a helical beam antenna is particularly sensitive to the phase velocity of wave propagation along the helix. In equation (14) it has been assumed that the relative phase velocity fulfills the maximum directivity condition⁹ such that the relative phase velocity, β , can be given by

$$\beta = \frac{L}{\sqrt{\frac{S}{\lambda} + 1 + \frac{1}{2\pi}}} \quad (15)$$

where β is the ratio of the phase velocity of wave propagation along the helix conductor to the velocity of light in free space. Although the agreement of (15) and the measured velocity is usually close over a wide frequency range, any difference between the calculated and measured patterns usually can be largely accounted for by a difference between (15) and the actual velocity.

By means of the expressions pre-

Pitch angle . . . $a = 12.5^\circ$

Diameter . . . $D = 0.32 \lambda$

Spacing . . . $S = 0.22 \lambda$

Ground plane diameter . . . $G \geq 0.8 \lambda$

Spacing to ground plane . . . $g = 0.12 \lambda$

Conductor diameter . . . $d \cong 0.02 \lambda$

No. of turns, $n = \frac{12.300}{\beta^2}$

where the half-power beamwidth (β) is in degrees

No. of turns, $n = \frac{\text{Gain}}{3.3}$

Table II
 Design Dimensions for center frequency.

$$\text{Beamwidth (half-power)} = \frac{52}{\frac{C}{\lambda} \sqrt{n \frac{S}{\lambda}}} \text{ degrees}$$

$$\text{Beamwidth (first nulls)} = \frac{115}{\frac{C}{\lambda} \sqrt{n \frac{S}{\lambda}}} \text{ degrees}$$

$$\text{Power gain} = 15 \left(\frac{C}{\lambda} \right)^2 \frac{S}{n \lambda}; \text{ or power gain} = 11.8 + 10 \log_{10} \left[\left(\frac{C}{\lambda} \right)^2 \frac{S}{n \lambda} \right] \text{ dB}$$

$$\text{Axial ratio} = \frac{2n+1}{2n}$$

$$\text{Terminal resistance} = 140 \frac{C}{\lambda} \text{ ohms}$$

Note: The circumference (C), spacing (S), and free-space wavelength (λ) should be measured in the same units.

Table III
General formulas.

sented, it is possible to predict the important characteristics of helical beam antennas with sufficient accuracy for most engineering applications. Preferred dimensions, that can be used to design a helical beam antenna to produce either a specified beamwidth or power gain, are summarized in table II. They are for a helix with a 12.5° pitch angle and apply to the center frequency of operation; $C = 1.0 \lambda$.

The formulas for the number of turns are unreliable if n results in a value less than about 3. Thus, the formulas cannot be used reliably to calculate the number of turns if the beamwidth re-

quired is more than about 65° or the power gain less than about 10.

More general formulas are summarized in table III. These can be used to predict the characteristics over the frequency range of the beam mode (circumference between 3/4 and 4/3 wavelength or frequency between 3/4 and 4/3 of center frequency). These formulas are applicable to helices with pitch angles between 12° and 15°. In general, they are more accurate near the center frequency than near the frequency limits of operation. They are not reliable if n is less than 3. The dimensions G , g , and d should be as indicated in table II.

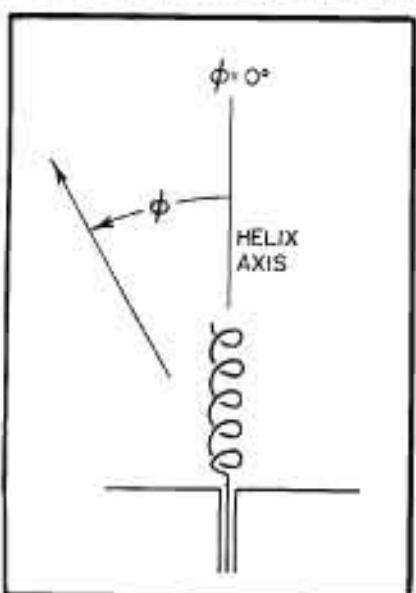
In some applications, helices with less than 3 turns may be desirable. Also values of α , G , g , and d , other than specified can be used. Although in such cases, the formulas given here may provide a rough approximation, they should be regarded as unreliable.

References

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- ⁸IRE Standards on Radio Wave Propagation (definitions of terms); 1942.

Figure 8

Relation of direction angle (ϕ) to helix axis.



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Last Minute Reports . . .

THE PROBLEM OF INTERFERENCE, particularly acute in the aircraft and TV fields, has prompted the development of a lab model standard noise generator by the military services. The generator, the result of several years work by the Purdue Research Foundation for the Air Forces, begun during the war, is said to be useable from below .150 mc to beyond 600 mc. Noise is simulated by generating pulses at various rates per second or on a random basis. . . . Neal McNaughten has succeeded Royal V. Howard as director of engineering for NAB. Before coming to NAB McNaughten was with the FCC for seven years. . . . The 1949 edition (675 pages) of the NAB Engineering Handbook will soon be available. Copies will be sent free to all NAB members and the price to others will be \$17.50. . . . K. F. Kellerman is now in charge of the Washington, D. C. office of Brush Development Company. . . . Art Cerf and Company, 744 Broad Street, Newark 2, New Jersey, will represent Raytheon in the upper New York State area for their voltage stabilizers.

. . . Grand Rapids, Michigan station WLAV-TV has installed a G. E. microwave system for video at 2,000 mc and audio in the 890-910 mc band. Receivers will be set up at Stevensville, Michigan, to pick signals from Chicago, where they will be relayed to Cedar Bluff, Michigan, and then to Grand Rapids. . . . The APRL Hudson Division will sponsor an amateur convention and show in the Ninth Regiment Armory, 125 West 14th Street, New York City, on October 7, 8 and 9. . . . KBTX, Dallas, Texas, will soon go on the air with a DuMont transmitter on channel eight. . . . R. H. Bacon, vice president of Kreicker and Meloan, Inc., industrial advertising agency, has been elected president of the Chicago Technical Societies Council. . . . John J. Doyle is now manager of electronic tube sales for the Westinghouse lamp division, Bloomfield, New Jersey. . . . C. A. Petry has been granted a leave of absence from his post as superintendent of telecommunications with United Air Lines in Denver to join the staff of Aeronautical Radio, Inc., in Washington, D. C. as director of the frequency division. . . . The Audio Engineering Society will sponsor a three-day exhibit at the Hotel New Yorker, New York City, on October 27, 28 and 29. . . . The Second Southwestern IRE Conference will be held in the Baker Hotel, Dallas, Texas, on December 9 and 10. . . .

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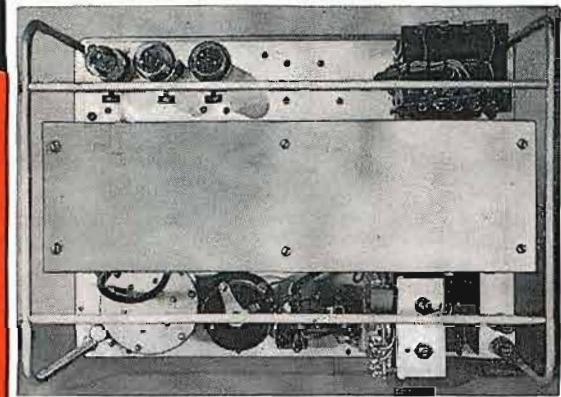
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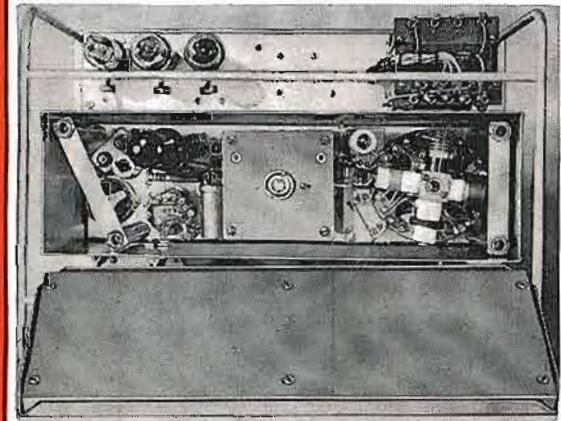
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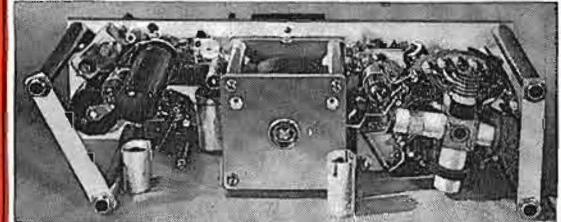
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OSCILLATORS GIVE YOU PRECISE TEST VOLTAGES from $\frac{1}{2}$ cps to 10 mc!

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Almost anywhere in America, -hp- field representatives can give you personal help with your measuring problems. They have complete data on -hp- instruments, their performance, servicing and adaptability. Call the nearest -hp- field representative whenever, wherever you need help with a measuring problem.

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-hp- MODEL 200C

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SPECIFICATIONS OF -hp- OSCILLATORS

INSTRUMENT	REQ. RANGE	OUTPUT	DISTORTION	REQ. RESPONSE	PRICE
-hp- 200A	35 cps to 35 kc	1 watt/22.5v	Less than 1%	\pm 1 db to 15 kc	\$120.00
-hp- 200B	20 cps to 20 kc	1 watt/22.5v	Less than 1%	\pm 1 db to 15 kc	130.00
-hp- 200C	20 cps to 300 kc	100 mw/10v	Less than 1% at 20 kc	\pm 1 db to 150 kc	150.00
-hp- 200D	2 cps to 70 kc	100 mw/10v	Less than 1% 10 cps to 70 kc	\pm 1 db throughout range	175.00
-hp- 200H	60 cps to 600 kc	10 mw/1v	Less than 2%	\pm 1 db, 60 cps to 600 kc	350.00
-hp- 200J	6 cps to 6 kc	100 mw/10v	Less than 1% above 10 cps	\pm 1 db, 6 to 6000 cps	225.00
-hp- 201B	20 cps to 20 kc	3 w/43.5v	Less than 1% (1 watt output)	\pm 1 db throughout range	250.00
-hp- 201B	1/2 cps to 50 kc	100 mw/10v	Less than 1% 1 to 1000 cps	\pm 1 db, 10 to 50,000 cps	300.00
-hp- 202D	2 cps to 70 kc	100 mw/10v	Less than 2% 10 cps to 70 kc	\pm 1 db, 7 cps to 70 kc	275.00
-hp- 204A (Battery Oper.)	2 cps to 20 kc	2.5 mw/5v	Less than 1%	\pm 1 db throughout range	175.00
-hp- 850A	10 cps to 10 mc	1.5 mw/3v	Less than 1% 100 cps to 100 kc	\pm 1 db throughout range	475.00

For complete details on any -hp- instrument, write direct to factory or contact the -hp- technical representative nearest you.

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